OHIO
U.S. Route 22 near Cambridge

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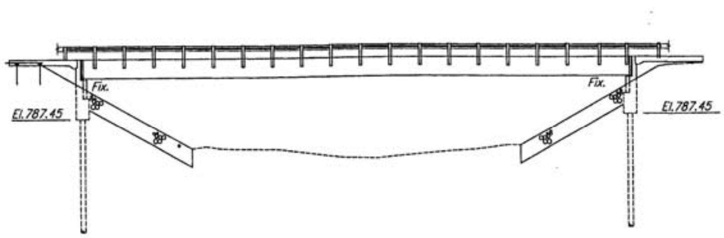
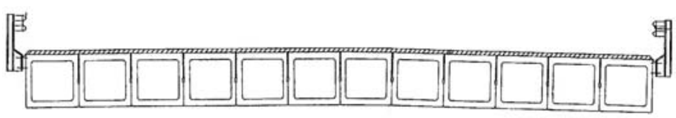
U.S. Route 22 near Cambridge

1. DESCRIPTION





Location:	U.S. Route 22 over Crooked Creek at Milepost 6.57 near Cambridge in Guernsey County
Open to Traffic:	November 1998
Environment:	Normal over water
HPC Elements:	Abutments and beams
Total Length:	116.5 ft
Skew or Curve:	None
Girder Type:	B 42-48 ODOT box beam
Girder Span Lengths:	One span of 115.5 ft
Girder Spacing:	Adjacent box beams
Girder Strand Grade:	270
Girder Strand Dia.:	0.6 in
Max. No. of Bottom Strands:	30
Deck Thickness:	5.5-in-thick top flange with 3-in-thick asphalt
Deck Panels:	None

2. BENEFITS OF HPC AND COSTS

A. Benefits of HPC

The original replacement bridge was designed as a three-span noncomposite bridge using 21-in-deep box beams. To save the cost of constructing the piers and to provide better flow characteristics by having an unobstructed channel, the bridge was redesigned as a single span. This was made possible through the use of 10,000-psi compressive strength concrete, 0.6-in-diameter prestressing strands, and a 42-in-deep box beam. HPC was also used in the girders because of its lower permeability. This is particularly important with adjacent box beams, as salt-laden water tends to penetrate into any longitudinal cracks that may form between adjacent beams.

B. Costs

Not Available

3. STRUCTURAL DESIGN

Design Specifications:	AASHTO Standard Specifications
Design Live Loads:	HS 25-44
Seismic Requirements:	None
Flexural Design Method:	AASHTO Standard Specifications
Maximum Compressive Strain:	0.003
Shear Design Method:	AASHTO Standard Specifications 9.20
Fatigue Design Method:	None
Lateral Stability Considerations:	Not applicable to adjacent box beams
Allowable Tensile Stress	
—Top of Girder at Release:	$7.5\sqrt{f'_{ci}}$ = 581 psi
—Bottom of Girder after Losses:	$6.0\sqrt{f'_{c}}$ = 600 psi
Prestress Loss:	19.6%
Method Used for Loss:	AASHTO Standard Specifications 9.16.2.1
Calculated Camber:	1.66 in at release 0.09 in final
Concrete Cover	
—Girder:	2 in on top, 2.5 in on side, 1.25 in on bottom
—Top of Deck:	—
—Bottom of Deck:	—
—Other Locations:	—
Properties of Reinforcing Steel	
—Girder:	ASTM A 615 Grade 60, uncoated
—Abutments:	ASTM A 615 Grade 60, epoxy coated
Properties of Strand	
—Grade and Type:	Grade 270, low relaxation
—Supplier:	Not available
—Surface Condition:	Clean
—Pattern:	8 strands debonded for 6 ft and 2 strands debonded for 3 ft in the bottom row See 10. DRAWINGS for details
—Transfer Length:	50 diameters = 30 in
—Development Length:	1.0 l_d from AASHTO Standard Specifications 9.28 for bonded strands 2.0 l_d for debonded strands

4. SPECIFIED ITEMS

A. Concrete Properties

	Girders (1)	Abutments (1,2)
Cementitious Materials Content:	946 lb/yd^3	972 lb/yd^3
Water/Cementitious Materials Ratio:	0.28	0.28
Min. Quantity of Fly Ash:	0	80 lb/yd^3
Max. Quantity of Fly Ash:	0	80 lb/yd^3
Min. Quantity of Silica Fume:	100 lb/yd^3	88 lb/yd^3
Max. Quantity of Silica Fume:	100 lb/yd^3	88 lb/yd^3
Min. Quantity of GGBFS:	0	80 lb/yd^3
Max. Quantity of GGBFS:	0	80 lb/yd^3
Maximum Aggregate Size:	3/8 in	3/8 in
Slump:	6-8 in	5-7 in
Air Content:	5-7%	5-7%
Compressive Strength		
—Release of Strands:	6000 psi	—
—Design:	10,000 psi at 56 days	8000 psi at 56 days
Chloride Permeability: (AASHTO T 277)	< 1000 coulombs at 56 days	< 1000 coulombs at 56 days
ASR or DEF Prevention:	Not specified	Not specified
Freeze-Thaw Resistance:	Dynamic modulus > 80%	Dynamic modulus > 80%
Deicer Scaling:	Not specified	Not specified
Abrasion Resistance:	Not specified	Not specified
Other:	—	—

(1) Concrete mix proportions were included in an Addendum to the specifications. Contractor was allowed to submit an alternative mix design.
(2) Mix could contain either fly ash or GGBFS at the quantities listed.

B. Specified QC Procedures

Girder Production	
Curing:	Steam
Internal Concrete Temperature:	—
Cylinder Curing:	Cylinders for release strengths cured alongside beams. All other cylinders used AASHTO T 23 Standard Cure
Cylinder Size:	6x12 in
Cylinder Capping Procedure:	Unbonded neoprene caps
Cylinder Testing Method:	AASHTO T 22
Frequency of Testing:	One set of cylinders per beam for testing at release, 7, 28, and 56 days
Other QA/QC Requirements:	—

Abutment Construction	
Curing:	Wet burlap and soaker hoses for 7 days
Cylinder Curing:	AASHTO T 23 Standard Cure
Cylinder Size:	6x12 in
Flexural Strength:	—
Other QA/QC Requirements:	—

5. CONCRETE MATERIALS

A. Approved Concrete Mix Proportions (3)

	Girders	Cast-in-Place Abutments
Cement Brand:	Not available	Not available
Cement Type:	III	I
Cement Composition:	Not available	Not available
Cement Fineness:	Not available	Not available
Cement Quantity:	846 lb/yd^3	803 lb/yd^3
GGBFS Brand (4):	—	Holnam
GGBFS Quantity:	—	75 lb/yd^3
Fly Ash Brand (4):	—	National Minerals
Fly Ash Type:	—	F (5)
Fly Ash Quantity:	—	68.5 lb/yd^3
Silica Fume Brand:	Master Builders Rheomac SF100	Master Builders Rheomac SF100
Silica Fume Quantity:	100 lb/yd^3	87.5 lb/yd^3
Fine Aggregate Type:	Natural river sand	Natural river sand
Fine Aggregate FM:	3.06	Not measured
Fine Aggregate SG:	2.63	2.65
Fine Aggregate Quantity:	927 lb/yd^3	868 lb/yd^3
Coarse Aggregate, Max. Size:	3/8 in	3/8 in
Coarse Aggregate Type:	Crushed river gravel	River gravel (6)
Coarse Aggregate SG:	2.71	2.59
Coarse Aggregate Quantity:	1774 lb/yd^3	1721 lb/yd^3
Water:	262 lb/yd^3	210 lb/yd^3
Water Reducer Brand:	—	—
Water Reducer Type:	—	—
Water Reducer Quantity:	—	—
High-Range Water-Reducer Brand:	Master Builders Rheobuild 1000	Master Builders Rheobuild 1000
High-Range Water-Reducer Type:	A and F	A and F
High-Range Water-Reducer Quantity:	203 fl oz/yd^3	191.8 fl oz/yd^3 w/fly ash 193.0 oz/yd^3 w/slag
Retarder Brand:	Master Builders Pozzolith 100-XR	— —
Retarder Type:	B and D	—
Retarder Quantity:	28 fl oz/yd^3	—
Corrosion Inhibitor Brand:	—	—
Corrosion Inhibitor Type:	—	—
Corrosion Inhibitor Quantity:	—	—

	Girders	Cast-in-Place Abutments
Air Entrainment Brand:	Master Builders MB AE 90	Master Builders MB AE 90
Air Entrainment Type:	Anionic surfactant	Anionic surfactant
Air Entrainment Quantity:	21 fl oz/yd^3	31.6 fl oz/yd^3 w/fly ash 24.0 oz/yd^3 w/slag
Water/Cementitious Materials Ratio:	0.28	0.22

(3) Mix proportions for the girders and the abutments were developed by the research team.
(4) Mix proportions for the abutments were developed for concrete containing either fly ash or slag.
(5) The contractor was allowed to use Class C for the actual abutments.
(6) The contractor was allowed to substitute crushed limestone for the actual abutments.

B. Measured Properties of Approved Mix

	Girders	Abutments
Slump:	3 in	8.5 in w/fly ash 5.0 in w/slag
Air Content:	5.8%	5.5% w/fly ash 4.0% w/slag
Unit Weight:	Not measured	Not measured

Compressive Strength:
Cylinder size was 6x12 in

Age, days	Compressive Strengths (AASHTO T 22), psi						
	Trial Mix (7)	Beams (8)				Abutments (9)	
		ASTM Cure (10)		Beam Cure (11)			
		A	B	A	B	Fly Ash	Slag
1	8935	7285	5880	8490	—	—	—
3	9450	8965	7415	9290	8560	5215	7150
7	9805	9870	8125	9720	8850	6565	8870
12	—	10,550	9385	9770	9205	—	—
21	—	11,325	9595	10,200	8960	—	—
28	10,780	11,540	10,400	10,250	9720	8265	10,380
56	—	12,460	11,015	—	—	8565	10,745

(7) Strengths obtained during trial mixes.
(8) Properties measured from concrete used in prototype beams A and B.
(9) Properties were measured for concrete containing either fly ash or slag.
(10) AASHTO T 23 (ASTM C 31) Standard Cure.
(11) Steam cured with beams, then moist cured until tested.

Modulus of Elasticity, Modulus of Rupture, Splitting Tensile Strength, Shrinkage, Chloride Permeability, Alkali-Silica Reactivity, Freeze-Thaw Resistance, and Abrasion Resistance:

Age (12), days	Beams (13)	Abutments (14)	
		Fly Ash	Slag
Modulus of Elasticity (ASTM C 469), ksi			
56	4647	4447	5259
Modulus of Rupture (AASHTO T 97), psi			
7	1080	—	—
28	1140	925	1000
56	1250	—	—
Splitting Tensile Strength (AASHTO T 198), psi			
7	520	—	—
28	640	550	650
56	620	—	—
Shrinkage (AASHTO T 160), millionths			
124	—	410	460
150	900	—	—
Chloride Permeability (AASHTO T 277), coulombs			
56	342	—	—
56	358	—	—
Alkali-Silica Reactivity (AASHTO T 299), %			
56	—	2.05	1.08
Freeze-Thaw Resistance (AASHTO T 161, Procedure A), %			
56	86.1	80	55
Abrasion Resistance (ASTM C 944), in			
56	—	< 0.02	< 0.02

(12) All specimens were cured per AASHTO T 23 Standard Cure prior to test age.
(13) Properties measured from concrete used in prototype beams.
(14) Properties were measured for concrete containing either fly ash or slag.

6. CONCRETE MATERIAL PROPERTIES

A. Measured Properties from QC Tests of Production Concrete for Girders

Cement Composition:	Not available
Actual Curing Procedure for Girders:	Steam for 18 hours
Slump:	4.75 to 7.75 in (Average = 6 in)
Maximum Girder Temperature:	—
Air Content:	6-7%
Unit Weight:	Not measured
Compressive Strength:	All tests were conducted as part of the research program. (See section 6C for results.)

B. Measured Properties from QC Tests of Production Concrete for Abutments

Cement Composition:	Not available
Actual Curing Procedure for Abutments:	Wet burlap and soaker hoses for 7 days

Slump, Air Content, Unit Weight, and Compressive Strength:

Batch (15)	Slump, in	Air Content, %	Unit Weight, lb/ft^3	Compressive Strength, psi (16)
1	4	5.0	144	10,300
2	4	5.5	144	10,360
3	5	5.0	145	10,405
4	5	7.5	139	9450
5	4.5	6.0	143	7020
6	5	8.5	135	5510
7	—	5.0	141	6930
8	4	7.0	140	9130
9	5	7.5	138	8430
10	4	7.5	140	9350
Average	4.5	6.5	141	8689

(15) Used in Phase II abutments.
(16) Measured on 6x12-in cylinders, cured per AASHTO T 23 Standard Cure, and tested at 28 days per AASHTO T 22

C. Measured Properties from Research Tests of Production Concrete for Girders

Compressive Strength:
(AASHTO T 22)

Beam No.	Age, days			
	1	7	28	56
1	8220	9360	11,810	12,490
2	8130	9490	11,830	12,920
3	7760	9390	11,670	12,270
4	7480	8620	10,590	11,460
5	7330	9250	11,180	11,570
6	9210	9780	11,960	12,420
7	6670	7750	9840	9570
8	7870	8940	11,520	12,030
9	7800	9170	11,670	12,050
10	8010	9050	11,630	11,830
11	7700	8580	10,340	11,100
12	7500	9340	11,460	12,040
Average	7810	9060	11,290	11,810

All tests were made on 6x12-in cylinders. Cylinders for release strengths were cured alongside beams. All other cylinders used AASHTO T 23 Standard Cure.

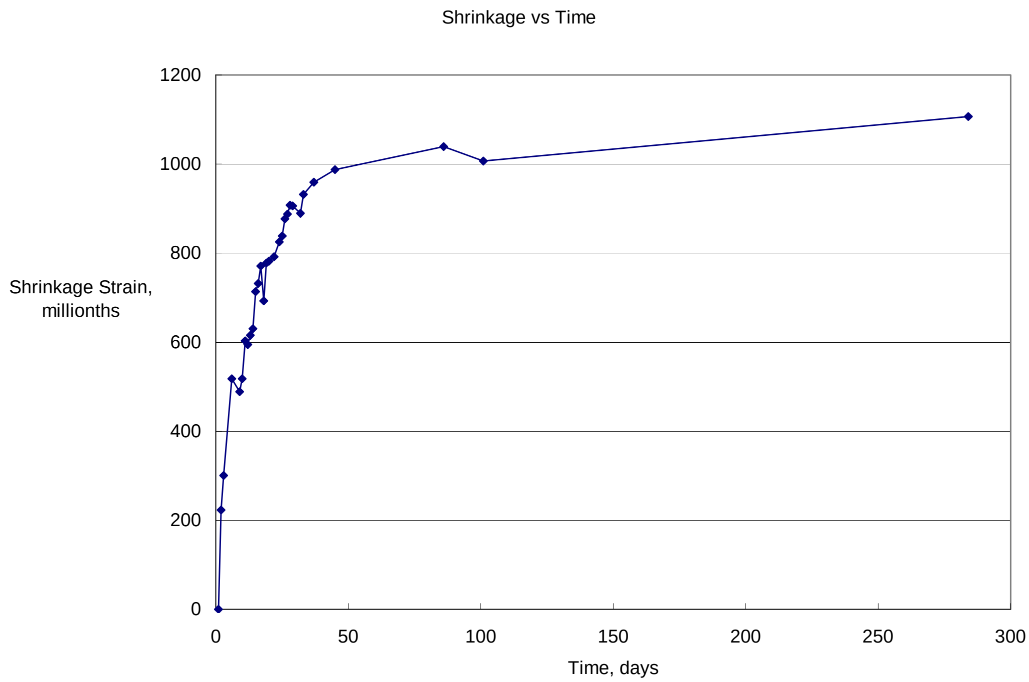
Chloride Permeability: 167, 180, and 292 coulombs at 10-1/2 months
(AASHTO T 277)

Creep
(ASTM C 512)

Specimen: 6x12-in cylinder
Loading: 4000 psi applied at concrete age of 7 days
Curing: Inside molds for 1 day followed by moist room curing until loaded

See Excel file for data.

Shrinkage (AASHTO T 160)	
Specimens:	3x3x11.25 in
Curing:	Inside molds for 1 day followed by moist room curing until testing began



See Excel file for data.

D. Measured Properties from Research Tests of Production Concrete for Abutments

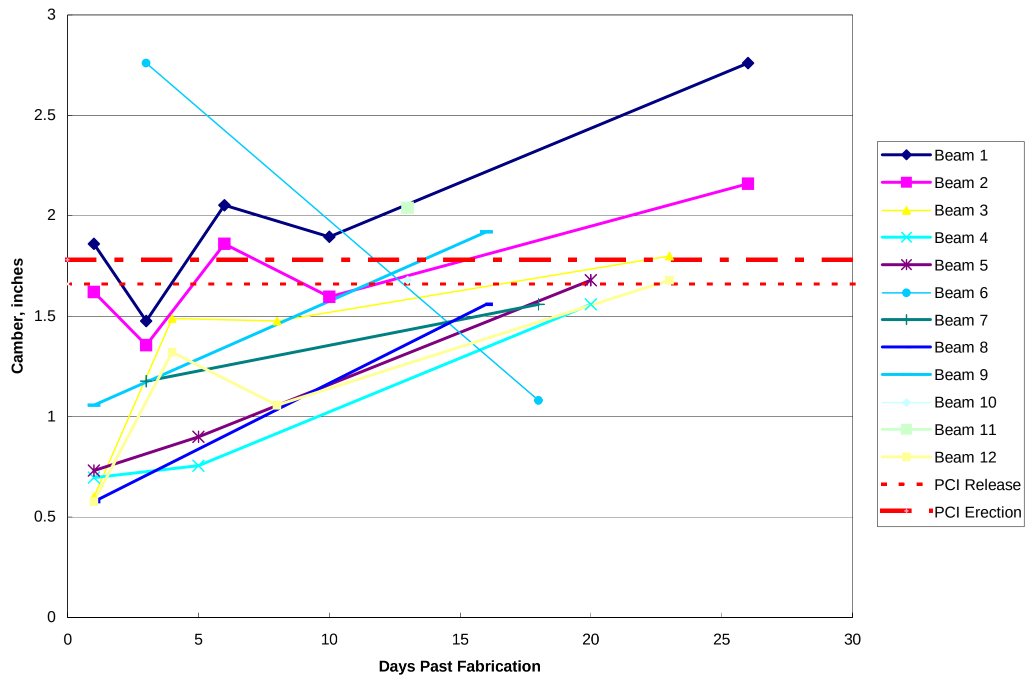
Nothing reported.

7. OTHER RESEARCH DATA

Curing Temperatures: Maximum measured concrete temperature in end blocks = 175 ^{o}F

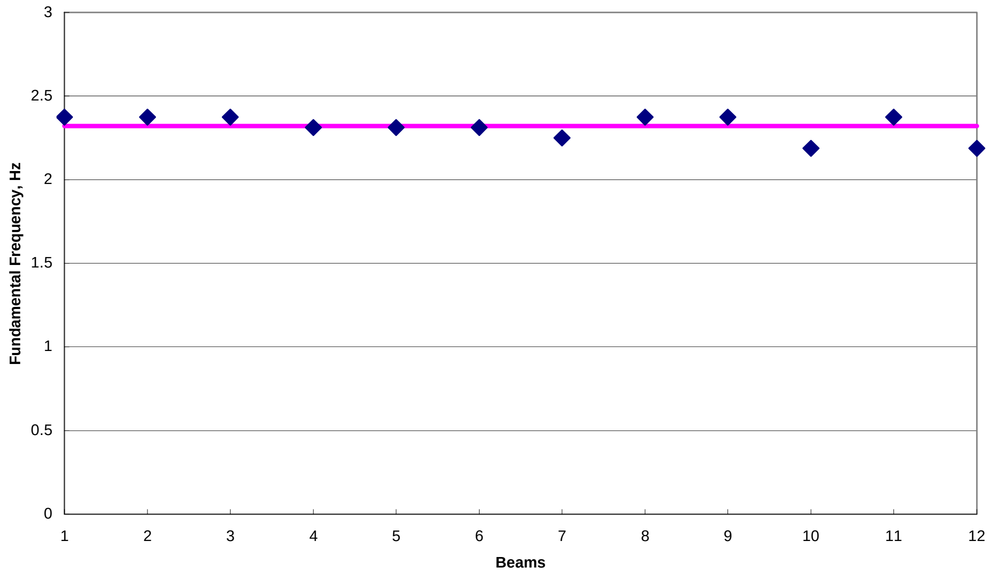
Prestress Losses: Not available

Camber:



Transfer Length: Between 36 and 48 in as measured on prototype beams

Modal Testing of Beams:



Fundamental Frequencies of Bridge Beams

Modal Testing of the Completed Bridge:

Mode		Frequency, Hz
No.	Type	
1	First Bending	1.98
2	First Torsion	4.03
3	Second Bending	7.10
4	First Butterfly	7.95
5	Second Torsion	9.84
6	Third Bending	15.66
7	Second Butterfly	15.76
8	Third Torsion	18.18
9	Third Butterfly	24.96
10	Fourth Bending	27.61
11	Fourth Torsion	29.42
12	Fourth Butterfly	36.15

Live Load Tests:

The bridge was constructed in two phases. In phase I, seven girders were erected. In phase II, the remaining five girders were erected to complete the bridge. A truck load test was conducted after the completion of each phase. These test consisted of using up to four dump trucks, each weighing approximately 30 kips, placed on the bridge in different configurations.

According to the final report, the tests showed the following:

1. Maximum static deflections were 35 to 50 percent of that allowed by the *AASHTO Standard Specifications*. The deflections were consistent with those expected to occur if the beams were acting together as a single monolithic unit.
2. The maximum live load stress, computed from measured strain, under static loading was about 500 psi. This was in reasonable agreement with the design values. The strains were consistent from beam to beam, confirming that the beams were acting together as a single unit.
3. Under dynamic loading caused by dump trucks traveling at about 50 mph, the bridge did not vibrate excessively. The damping was calculated to be about 1.5 to 2 percent of critical. Dynamic deflections were about equal to static deflections with no apparent dynamic magnification.

8. OTHER RELATED RESEARCH

Prior to construction of the bridge, two prototype beams were fabricated for the following purposes:

1. Determine whether the HPC mix, developed in the laboratory, would perform adequately under actual fabrication and service conditions.
2. Allow the fabricator to gain experience with using an HPC mix.
3. Determine the structural behavior of the beams through non-destructive testing and to see if the behavior was predictable.

The beams were instrumented to measure temperatures in the end blocks from heat of hydration, transfer length, and camber. Both beams were subjected to fatigue loading followed by a test to determine the flexural capacity. The fatigue loading was intended to represent the passage of a single HS 20 truck taking into account the load distribution factor and impact factor. For the first beam, the applied loads were only one half of the intended loads and the test results were discarded. The second beam was intentionally cracked prior to subjecting it to 653,000 cycles of loading. No fatigue effects were evident based on deflection and strain response. Following the fatigue test, the beams were loaded through two point loads spaced at 5-1/2 ft in a series of deflection increments.

Conclusions from the two beam tests were reported as follows:

1. High performance/high strength concrete can be used with 0.6-in-diameter strands to extend the spans of precast, prestressed concrete beams.
2. Transfer length was between 36 and 48 in.
3. Camber at release was 0.25 in—well below the calculated camber of 1 in.
4. The measured prestress losses at the time when the girders were loaded to crack them were 17 and 18 percent. This compares with 20 percent calculated using the *AASHTO Standard Specifications*.
5. The cracking moment was 21 percent higher than the cracking moment calculated using *AASHTO Standard Specifications*.
6. Measured flexural strengths were 4 percent greater than values calculated using the *AASHTO Standard Specifications*.

9. SOURCES OF DATA

Baseheart, M. T., Miller, R. A., and Sharooz, B. M., "Use of High Performance Concrete for an Abutment Box Beam Bridge, Guernsey County, Ohio, Bridge # GUE-22-0657," Final Report, Contract # 8226, Cincinnati Infrastructure Institute, University of Cincinnati, July 2000, 144 pp.

Greuel, A., Baseheart, T. M., Rogers, B. T., Miller, R. A., and Sharooz, B. M., "Evaluation of a High Performance Concrete Box Girder Bridge," *PCI Journal*, Vol. 45, No. 6, November/December 2000, pp. 60-71.

SHRP High Performance Concrete Bridge Showcase Notebook, Cincinnati, OH, February 23-24, 1999.

Long, E. E., "High Performance Concrete Mix Design for an Adjacent Box Girder Bridge," A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Department of Civil and Environmental Engineering, University of Cincinnati, 1998, 147 pp.

Jones, J. M., "Design, Construction, and Testing of a 35.5 m (116' 6") Prestressed Box Girder, Utilizing 15.2 mm (0.6") Prestressing Strand and High Performance Concrete (HPC)," A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Department of Civil and Environmental Engineering, University of Cincinnati, 1998, 165 pp.

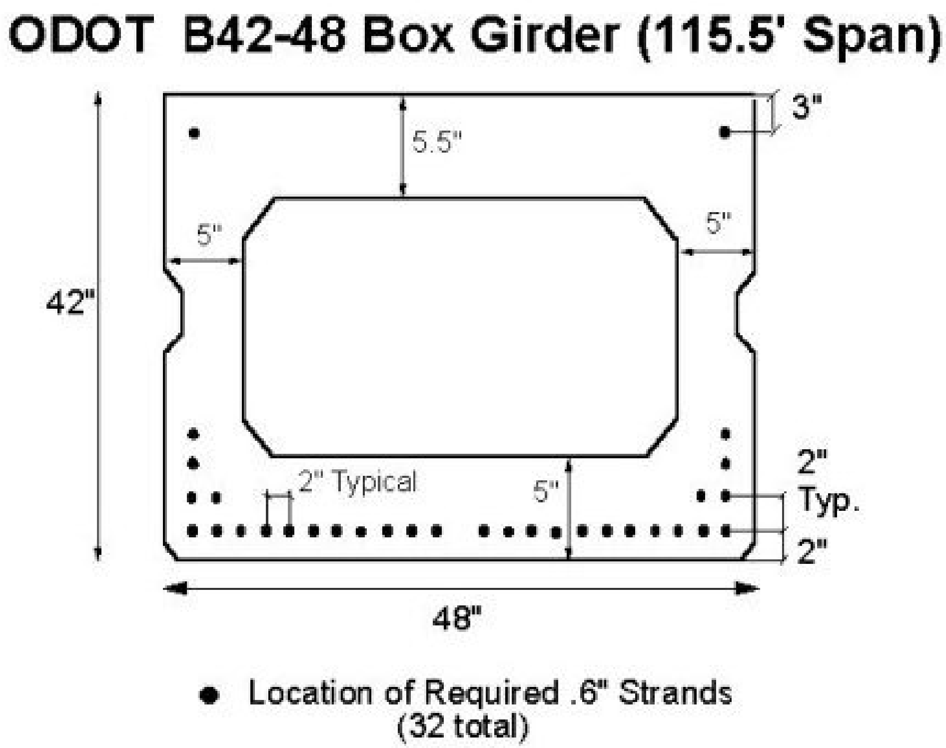
Knarr, R. L., "An Analytical and Experimental Investigation of a Prestressed Box Girder," A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Department of Civil and Environmental Engineering, University of Cincinnati, 1995, 139 pp.

Greuel, A. S., "Truck Load Testing of Bridge GUE-22-6.57," A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Department of Civil and Environmental Engineering, University of Cincinnati, 2000, 134 pp.

Rogers, B. D., "An Exploration of the Behavior and Properties of Bridge GUE-22-6.57," A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Department of Civil and Environmental Engineering, University of Cincinnati, 2000, 140 pp.

Richard A. Miller, University of Cincinnati, Cincinnati, OH.

10. DRAWINGS


ODOT B42-48 Box Girder (115.5' Span)
3"
5.5"
5"
5"
42"
2" Typical
5"
2"
Typ.
2"
48"
Location of Required .6" Strands
(32 total)

11. HPC SPECIFICATIONS

SCOPE AND PURPOSE OF THIS ADDENDUM:

This addendum is supplied in place of a pre-bid meeting to facilitate the bidding process and to more easily include all interested parties.

This bridge (GUE-22-6.57) has been declared a "special features" bridge by both the Ohio Department of Transportation (ODOT) and the Federal Highway Administration (FHWA). The special features designation means that the bridge has several unusual or experimental features.

There are specific notes and items on the bridge drawings and/or related bid documents which cover these special features. This addendum covers many of those special notes and items and supplies some additional information which was not available when the drawings were filed. In the event of conflict between the drawing and this addendum, this addendum shall supersede the drawing. Also, for any item covered in the drawings but not addressed in this addendum, the drawing shall be considered in force.

Bidders on this project are directed to carefully read the drawings, associated bid documents and this addendum. It is assumed that all bidders have read and understood the drawings and related documents. It is further assumed that all bidders are prepared to comply with the terms of these documents and have incorporated these terms into their bid. No additional funds or allowances will be made for materials, labor, delays, etc. which are needed to provide the special features or comply with the terms of contract concerning these special features. In addition, the contractor shall be solely responsible for communicating with and instructing subcontractors as to the provisions of the drawings, related bid documents and this addendum.

Bidders with questions concerning the special features of the bridge and any related notes and items should contact ODOT prior to submitting a bid. It is suggested that all questions be submitted in writing.

SPECIAL FEATURES

This bridge is a research demonstration project developed to demonstrate that the use of high performance concrete in box beam bridges can increase the usable span length of this type structure, thus achieving a more economical bridge and extending ODOT and FHWA funds. Beyond the structural gains, high performance concrete=s low permeability and high durability will enhance and improve the durability of this type of structure decreasing the bridge=s life cycle costs.

A University of Cincinnati Research Team (UCRT) is responsible for assuring the research program is completed and provides accurate and useful data, testing information and construction documentation. The research program includes:
Development of high performance concrete mix designs.
Testing of two full scale sample prestressed box beams.
Internal instrumentation of the prestressed box beams to be used in the project.
Internal instrumentation of the project=s substructure units including partially completed portions of the structure due to phased construction.

Field testing of the fabricated box beams and the overall structure, in all phases, to monitor erection stresses, live load distribution, live load capacity, thermal effects, and other environmental effects that can affect the behavior and capacity of the structure.

The research includes video recording of all phases, including the fabrication, erection and construction sequences to document those processes for future presentation to interested parties. The concrete mix designs and the full scale sample prestressed box beam testing have been completed prior to this bridge project.

SPECIFIC REQUIREMENTS FOR THE SPECIAL FEATURES AND CONDUCT OF THE RESEARCH

Access to site:
The Contractor and subcontractors, the Engineer and UCRT will need to work as a team to complete the mutual goals of constructing a needed structure, gathering test data to assure the structure=s quality and documenting the bridge construction process. At all times, the Contractor, and subcontractors, shall give UCRT free and clear access to the site, including various portions and phases of the bridge, to allow for installation of instrumentation and testing of the instruments and to run actual tests required to complete the project.

Free and clear access shall be defined as:

1) The contractor and subcontractors shall allow members of the UCRT on site at any time.
2) In addition to making the site available to UCRT during normal working hours, the contractor and subcontractors shall make the site available to the UCRT after hours and on weekends, as necessary, for UCRT to do its work.
3) The contractor and subcontractors shall, on request and with reasonable speed, move or remove any equipment, forms, temporary structures, etc., which inhibit UCRT from gaining needed access to any part of bridge.
4) The contractor and subcontractors shall delay, stop or move, as required, any construction processes which interfere with UCRT's placement of instruments, monitoring of instruments or testing.
5) The contractor and subcontractors shall allow UCRT to bring to site and use temporary scaffolding, ladders, lift buckets, etc. to gain access to parts of the bridge as needed. Any device or structure (e.g. ladders) used by UCRT to gain access shall be provided by UCRT unless prior arrangement has been made with the Contractor.

REQUIREMENTS FOR NOTIFICATION DURING CONSTRUCTION PHASES

During this project, UCRT will be installing and monitoring instrumentation and performing testing. This will require members of the UCRT to be on site at various times. It is not practical or necessary to have a member of the UCRT on site at all times, therefore it is necessary for the contractor to inform ODOT and UCRT of when various tasks will be accomplished so that representatives of ODOT and UCRT can be present, as needed.

The contractor shall notify both the Engineer and UCRT=s designated representative three (3) working days before the completion of forming and placing of reinforcing bars in areas where instrumentation is to be installed. No concrete shall be placed until instrumentation has been installed and tested by UCRT. A explanation of the instrumentation to be installed can be found in a following section.

The Contractor shall notify both the Engineer and UCRT at least three (3) days before the placement of any concrete that includes instrumentation so a representative of UCRT can be present during the concrete placement. The contractor shall allow UCRT sufficient time to install instrumentation in the interval between the completion of the installation of formwork and reinforcing and the pouring of the concrete. Time requirements are found in the section on instrumentation.

UCRT will monitor beam stresses and cambers while the prestressed beams are in storage. The contractor needs to notify the Engineer and UCRT at least three (3) days before the beams are loaded for transport so that all instruments can be disconnected from the data acquisition system and so that UCRT can assure the instrumentation protection is secure, make any needed adjustments, and assure instrumentation is in working order before and during shipping.

The prestressed beams will arrive on the job site with embedded instrumentation. The beams will be numbered (according to the numbering system given below) and must be placed in the bridge in the correct order. Also, care must be taken to avoid damaging the instruments or related items. The Contractor shall notify the Engineer and UCRT three (3) working days before erection of the beams so a UCRT representative can be present during erection.

As part of this research project, UCRT will be monitoring the instrumentation during construction to record construction loads, conducting nondestructive testing and proof testing of the beams and bridge under live load conditions. While some testing will be after normal working hours or on weekends, some testing must be performed during the actual construction time. UCRT will provide the Contractor and the Engineer with three (3) working days notice of it=s intent to test. The Contractor shall make the site available and shall not perform construction processes that will interfere with the testing. Some of the tests may require the Contractor to shut off power equipment and generators.

PROTECTION OF INSTRUMENTATION, WIRING AND DATA ACQUISITION EQUIPMENT DURING CONSTRUCTION

The Contractor shall take all necessary steps to assure installed instrumentation is not disturbed or damaged during the concrete placement. If instrumentation is damaged, the Contractor shall not attempt to repair, restore, replace or reconnect any instrumentation, but shall stop or move the concrete placement operations allowing access and time for the UCRT representative to repair the damage. Should an instrument be displaced or damaged, the UCRT representative will attempt to repair these instruments with as little disruption to the concrete placement operation as possible. However, UCRT does not guarantee that it can repair damaged instruments within a reasonable time frame to prevent serious disruptions of the concrete placement operations or the occurrence of cold joints. The Contractor is responsible for any delay time caused due to repairing damaged instrumentation and any material rejection of construction joints that may occur due to the delay.

The Contractor shall not move, dislodge, disturb, disconnect, reconnect, cut or relocate wires, instruments or related instrumentation controls or recorders or remove any labeling of the instruments, wires or related instrumentation controls or recorders.

The prestressed box beams will have embedded instrumentation when arriving at the bridge site. Connection wires to the instrumentation will be in electrical boxes which will project from the beams near the ends. Even though these wires and boxes will have been secured to the beams during transport and erection, the Contractor shall take care to not damage the boxes or disturb, disconnect or cut these wires.

If, during construction, any instruments or wires need to be moved or adjusted, the UCRT representative shall move or adjust the wires. The Contractor shall provide any needed access to the beams to make the required adjustments.

ITEM 515 - FABRICATION OF THE PRESTRESSED BOX BEAMS (115') B42-48 AS PER PLAN

This section is in addition to the requirements of item 515 and all related ODOT specifications.

The prestressed box beams for this project shall be purchased, manufactured and supplied by Prestress Service Inc., of Melbourne, Kentucky (PSM). The concrete for the prestresssed box beams shall have a minimum 56 days design strength of 10,000 psi. Minimum concrete strength at release of prestressing strands shall be 6000 psi. The concrete at 56 days shall have a rapid chloride permeability value of less than 1000 coulombs when tested following the current version of AASHTO T277. The concrete mix design for the prestressed concrete shall be supplied by UCRT. The proposed mix design is furnished at the end of this section. The Contractor and/or fabricator may submit suggested mix design alternatives, but alternate mix designs shall only be used with approval of the Engineer and UCRT. No alternative mix design will be acceptable without the submittal of actual test data results for compressive strength and rapid chloride permeability. No additional payment shall be given for any alternate mix design.

Prestressing strand shall be ASTM A416, 0.6" diameter, $f_s' = 270$ ksi, low relaxation strand. Initial tension shall be 0.75 f_s'. Due to possible tangling of the strand, each strand shall be pre-tensioned to a 3 kip load, then each strand shall be further pretensioned until a total load of 5 kips has been applied to each strand. At the 5 kip load the strands shall be marked, brought to required initial tension, and the total elongation measured. The total elongation shall be within specification to assure the proper initial tension has been achieved.

Mix design for prestressed beams:

CEMENT:	846 #/cy	
MICROSILICA:	100 #/cy	(11.8% Addition)
WATER:	262 #/cy	(w / c+p = 0.28)
SAND:	927 #/cy	
COARSE AGG.:	1774 #/cy	(3/8" MAXIMUM)
AIR:	5% - 7%	(2.5 oz/cwt; 21 oz total)
PLASTICIZER:	203 oz/cy	(24 oz/cwt)
RETARDER:	28 oz/cy	(3.3 oz/cwt)

SLUMP: 6" AFTER SP ADDED
f_{ci}' = 6000 psi minimum @ release
f_c' = 10000 psi @ 56 days
Rapid Chloride Perm: <1000 coulomb @ 56 days

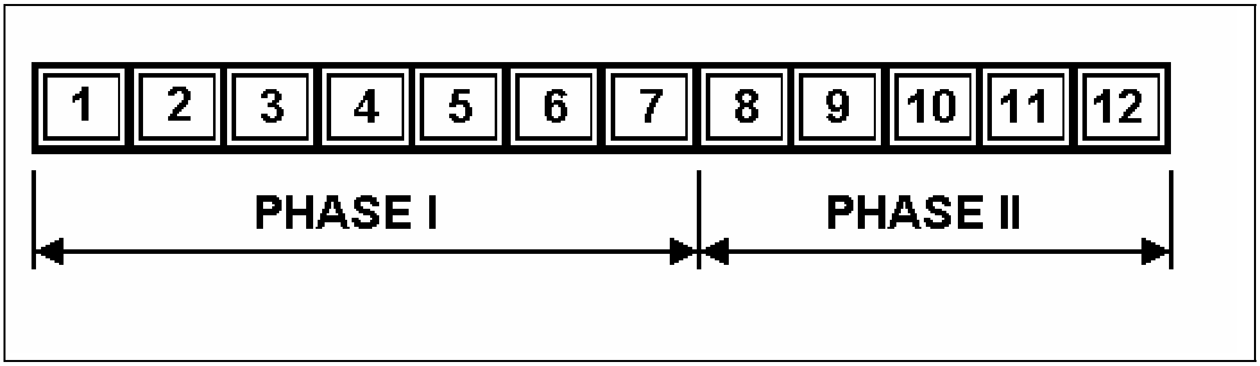
ITEM Special 530E00200 STRUCTURE, HIGH PERFORMANCE CONCRETE, FIELD TESTING

This item shall include all materials, labor, temporary and permanent access, electric, equipment and enclosures required by the University of Cincinnati Research Team (UCRT) to furnish the required access to install instrumentation and to perform tests of the high performance prestressed box beam structure during erection, installation and phasing. The tests will include instrumentation testing, monitoring during construction/erection, live load testing, periodic environmental testing during the length of the contract and other tests defined by UCRT. Testing will be performed for each phase.

The Contractor shall not be responsible for furnishing any testing equipment, testing instrumentation, wiring of the instrumentation, cabling connecting to the actual instrumentation, labor to physically install instrumentation or labor to perform the testing.
The contractor shall supply UCRT with a source of 115 V, 20 amp electricity 24 hours/day.

Numbering of the beams:

Due to various research related issues, there will be variations in the instrumentation associated with each prestressed beam. To facilitate the understanding of how the instrumentation will be placed, a numbering system has been established. The numbering shall be such that the facia beam of Phase I shall be Beam #1 and the remaining beams will be numbered consecutively (e.g. the final beam of Phase I will be #7, the adjoining beam of Phase II will be Beam #8 and the facia beam of Phase II will be Beam #12. The figure below shows the bridge beam numbering system.



Description of the Tests and Instrumentation:

Abutment Instrumentation: To measure the bearing pressure under the prestressed beam, one (1) pressure sensor shall be installed under each end of five (5) beams, for a total of ten (10) instruments. These sensors will be installed by tying them to the abutment reinforcing bar and/or formwork after the formwork and reinforcing bar for the abutments have been placed. The sensors will be placed under beams #3, 4, 5, and 6 in Phase I and under beam # 8 in Phase II (see figure above for numbering).

The contractor is notified that these instruments may extend slightly above the final surface of the concrete and may interfere with finishing. A UCRT representative will be present to assist during the finishing operation to assure the gages are not disturbed and are properly set. Should any work need to be done to the abutments after the concrete has set (e.g. grinding to level the surface), the contractor shall notify UCRT and shall not begin the work until a UCRT representative is present to assure the gages are not damaged. The contractor is further notified that wires from these instruments will be run within the abutment and tied to reinforcing bar. The ends of wires will be passed through holes drilled in the form work. After the forms are removed, the wires will be placed in electrical boxes attached to the surface of the abutment. These boxes will project beyond the face of the abutment and the contractor must take case so as not to disturb or damage these boxes or the wires inside.

In each phase, the UCRT will need at least 1 day of clear weather (the instruments cannot be placed in inclement weather) after the forms have been set and the reinforcing bar placed to complete installation and testing of the instruments. One half of a day of clear weather will be needed after removal of the formwork, in each phase, for installation of electrical boxes. As set forth in the paragraph above, the contractor shall make arrangements with the engineer at least 3 days in advance to schedule installation of the abutment instrumentation.

Prestressed Beams - Fabrication: Several vibrating wire and foil strain gages shall be installed, internally, during the fabrication process. The fabricator, Prestressed Services of Melbourne (PSM), has been advised of the instrumentation requirements. The instrumentation will be installed by UCRT. Because of previous experience with fabrication of test beams for the research associated with this project, PSM is already familiar with the requirements for special handling of both the concrete and the beam due to presence of the instrumentation. All extra costs for the special features of this beam, including this related to Item 515, will be incorporated in PSM's fabrication price to the Contractor.

Prestressed Beams - Transportation: Transportation of prestressed beams shall be arranged between PSM and Contractor. The Contractor is notified that standard electrical boxes will be attached to the bottom of the beams at one or both ends. These boxes will be installed by UCRT after the fabrication of the beams and will project below the bottom the beams. The purpose of these boxes to contain the ends of wires connected to the internal instrumentation. The beams shall be stored, loaded, transported and unloaded in a manner which will not damage or disturb these boxes.

Prestressed Beams - Erection: As noted in the preceding paragraph, the prestressed beam will arrive at the site with standard electrical boxes attached to the bottom at one or both ends. These boxes will project below the bottom of the beam. UCRT will install the boxes such that they will not interfere with seating the beams on the abutments. The contractor shall erect the beams in a manner such that these boxes will not be damaged or disturbed.

The instrumentation in each beam is different and the beams must be placed in the correct order. Prior to shipment, UCRT will mark each beam with a number indicating the correct placement within the bridge. The Fabricator and Contractor shall ship the beams such that they can be erected in the proper order. Furthermore, the ends of beams with the electrical boxes (as referenced in the previous paragraph) must be placed properly to allow for wiring of instrumentation. Prior to shipment, UCRT will mark each end of each beam as "forward" or "rear". These designations shall indicate placement of that end of the beam on the forward or rear abutment, as appropriate. The definition of forward and rear abutment shall be as given on the plans.

Placement of External Instrumentation and Wiring of Instrumentation: After erection of the beams and casting of the shear keys, UCRT install differential deflection measuring devices at the joints between each beam. UCRT will then wire all instrumentation to a data collection system according to the following sequence:

1) UCRT will supply a box to house the data acquisition equipment. This box will be placed within the bridge right-of-way. The exact location of the box will be determined in consultation with the contractor so it is placed, as nearly as possible, out of the way of the construction operation.

2) UCRT will connect all of the electrical junction boxes (described in previous paragraphs) with conduit and connect all of the instruments to wires pulled through these conduits. The wires and conduits shall be connected to the data acquisition box.

It is anticipated that UCRT will need 5 working days of clear weather, in each phase, to accomplish this task. The contractor shall be permitted to continue work during the instrumentation wiring process, provided that work does not interfere with the installation or wiring process.

Field Testing: In each phase, the UCRT will conduct the following tests:

1) A modal (nondestructive) test of the dynamic response of the bridge;
2) Static truck load testing of the bridge where trucks are placed on the bridge in various patterns;
3) Dynamic truck load testing, where trucks are run over the bridge at various speeds.

UCRT will require 2 working days of clear weather for the modal testing and 4 working days of clear weather for the truck load testing. The modal testing can be done as soon as erection is complete and the asphalt layer is placed on the bridge. The truck load testing can be done as soon as the asphalt layer is placed on the bridge and the bridge is accessible to trucks. All testing for a phase must be complete before that phase is opened to traffic.

PRECONSTRUCTION MEETING

A pre-construction meeting shall be required no later than two weeks before the start of any fabrication or field site work. The following five (5) groups shall be represented at the meeting.

Engineer
UCRT representative
Contractor
Representative of the prestressed box beam fabricator, Prestress Services Inc., Melbourne, Kentucky
Representative of the Office of Structures.

The pre-construction meeting is to allow the Contractor, Engineer, UCRT and the fabricator to finalize the schedule for the project, including fabrication, construction and phased erection of both the prestressed box beams and the bridge structure, and help coordinate all 5 groups to minimize delays to the project.

Payment for the materials, labor, temporary and permanent access, electric, equipment and enclosures required by the University of Cincinnati Research Team (UCRT) shall be at the contract bid price for item Special - Lump Sum - Structure, High Performance Concrete, Field Testing and shall include all materials, labor, tools, equipment and incidentals to complete the item.

ITEM Special 530E00200 STRUCTURE, HIGH PERFORMANCE CONCRETE, FABRICATION TESTING

This item shall include all materials, labor, temporary and permanent access, electric, equipment and enclosures required to furnish the University of Cincinnati Research Team (UCRT) with access required to install instrumentation and perform tests of the prestressed box beams during fabrication of the high performance prestressed box beams at the Contractor=s fabricator, Prestress Services Inc. of Melbourne, Kentucky.

The Contractor and/or Fabricator shall not be responsible for furnishing any testing equipment, testing instrumentation, wiring of the instrumentation, cabling connecting to the actual instrumentation, labor to physically install instrumentation or labor to perform the testing.

The fabricator, Prestress Services Inc., of Melbourne, Kentucky, shall delay fabrication operations to allow for installation of test instrumentation, testing and collection of test data. Any access required by UCRT will be furnished by the fabricator during the fabrication time and until the prestressed box beams are physically shipped to the project site. An additional hold point during the shipping of the box beams may be required to assure the installed instrumentation is in working order and not damaged during fabrication, storage or shipping.

The Contractor or Fabricator shall notify both the Engineer and UCRT at least three (3) days before the forming of or placement of any concrete that includes instrumentation so a representative of UCRT can be present during the forming and concrete placement at the fabricator. The Contractor=s fabricator shall take all necessary steps to assure installed instrumentation is not disturbed or damaged during the concrete placement. If instrumentation is damaged, the Contractor=s fabricator shall not attempt to repair, restore, replace or reconnect any instrumentation, but shall stop or move the concrete placement operations at the prestress plant allowing access and time for the UCRT representative to repair the damage.

Should an instrument be displaced or damaged, the UCRT representative will attempt to repair any displaced or damaged instruments with as little disruption to the concrete placement operation as possible. However, UCRT does not guarantee that it can repair damaged instruments within a reasonable time frame to prevent serious disruptions of the concrete placement operations or the occurrence of cold joints. The Contractor and Fabricator are responsible for any delay time caused due to repairing damaged instrumentation and any material rejection of construction joints that may occur due to the delay.

The contractor or fabricator shall not move, dislodge, disturb, disconnect, reconnect, cut or relocate wires or remove any labeling of the instruments and instrumentation.

As part of the research the UCRT representatives will be monitoring the instruments during fabrication and storage. While some testing will be after normal working hours or on weekends, some testing must be performed during the actual fabrication. At the time the Contractor=s fabricator informs the Engineer and UCRT of the intent to place concrete, UCRT will inform the Contractor, fabricator and the Engineer whether UCRT intends to perform actual data collection from the embedded instrumentation during the concrete placement. The Contractor=s fabricator should work jointly with UCRT to assure that any ongoing fabrication processes do not interfere with the testing and/or data collection.

During fabrication, the UCRT will monitor concrete temperatures while the beam is being cured. All instrumentation to monitor temperature will be installed as stated in the previous section on prestressed beam fabrication. The instrumentation will be connected to the monitoring system during installation. Since the instrumentation will be monitored during the curing period when no work is done on the beam, no delay to the contractor is anticipated.

The UCRT will monitor stresses in the beam during release of the prestressing strands. All instrumentation to monitor stress will be installed as stated in the previous section on prestressed beam fabrication. The instrumentation will be connected to the monitoring system during installation. Since the instrumentation will be installed and running prior to cutting the strands, no delay in cutting the strands in anticipated. However, UCRT will need approximately 2 hours after cutting the strands to disconnect the instrumentation and measure the camber before the beam can be moved to storage.

UCRT will monitor beam stresses and cambers while the beams are in storage. This will cause no delay to the fabricator or contractor. However, the contractor needs to notify the Engineer and/or UCRT at least three days before the beams are loaded for transport so that all instruments can be disconnected from the data acquisition system.

Payment for the materials, labor, temporary and permanent access, electric, equipment and enclosures required to furnish the University of Cincinnati Research Team (UCRT) with access required to install instrumentation and perform tests of the prestressed box beams during fabrication shall be at the contract price bid for item Special - Lump Sum - Structure, High Performance Concrete, Field Testing and shall include all materials, labor, tools, equipment and incidentals to complete the item.

511 71100 102 CU YD CONCRETE, HIGH PERFORMANCE, ABUTMENT INCLUDING FOOTING, AS PER PLAN

In addition to the requirements of 511, the abutment (including footing) concrete shall meet the following requirements.

All cast in place concrete is to have a 56 days design strength of 8000 psi and a rapid chloride permeability of less than 1000 coulombs. Two concrete mix designs, developed by UCRT, are supplied at the end of this section. Note that the contractor may use either the fly ash mix or ground granulated blast furnace slag mix, at his option. However, the contractor may use only one of these mixes for the entire job and cannot change mixes once the job is begun without the written approval of the Engineer and UCRT.

The Contractor and fabricator may submit suggested mix design alternatives, but alternate mix designs shall only be used with approval of the Engineer and UCRT. No alternative mix design will be acceptable without the submittal of actual test data results for compressive strength and rapid chloride permeability. No additional payment shall be given for any alternate mix design. The 56 day strength is used because the concrete contains either microsilica and flyash or ground granulated blast furnace slag, all of which are pozzolans. These pozzolans tend to gain strength at later ages and using a 56 day strength provides a longer time frame to attain needed strength. To prevent construction delays, the concrete will be acceptable if the contractor uses the UCRT mix design and the concrete obtains a design strength of 7000 psi and a rapid chloride permeability of less than 1000 coulombs at 28 days. If an alternative mix design is submitted, approval of a 28 day acceptance strength will only be possible if sufficient test data is provided to assure that the required 56 strength of 8000 psi and the required permeability will be obtained.

The concrete shall be water-cured as per 511.14 Method (a).

Cast in place concrete mixes:

Fly ash mix (per cubic yard):

Cement	804 lb. - Type I
Fly Ash	80 lb. (10% replacement)
Microsilica	88 lb. (10 % addition)
Water	268 lb. (w/ (c+p) = 0.30)
Fine Aggregate	868 lb.
Coarse Aggregate	1722 lb.
Air Entraining Admixture	24 oz.*
High Range Water Reducer	260 oz.*
Air	5 - 7%
Slump	5 - 7" after adding HRWR

Ground Granulated Blast Furnace Slag (GGBS) (per cubic yard):

Cement	804 lb. - Type I
GGBS	80 lb. (10% replacement)
Microsilica	88 lb. (10 % addition)
Water	268 lb. (w/ (c+p) = 0.30)
Fine Aggregate	868 lb.
Coarse Aggregate	1722 lb.
Air Entraining Admixture	24 oz.*
High Range Water Reducer	194 oz.*
Air	5 - 7%
Slump	5 - 7" after adding HRWR

* Admixture dosages were determined using Rheobuild 1000 and Microair admixtures. Contractor and ready mix supplier should consult with their admixture supplier to determine proper dosages.

SHEAR KEYS, MIDDEPTH

The shear keys are to built using the modified, middepth design shown. The surface of the keyway shall be prepared by sandblasting in accordance with current specifications. Only the middepth shear key is to be grouted with nonshrink grout. Under no circumstances shall the nonshrink grout be poured to a height above the top of the middepth shear key. Grout shall be selected from the approved list from those nonshrink grouts specifically designated by the manufacturer as being usable in the flowable or fluid condition. The contractor shall control the water content such that the grout will properly flow into the and fill the middepth shear key but not exceed the manufacturer's specified maximum water content. Backer rod shall be used as required to prevent leakage. The contractor shall properly rod and/or otherwise consolidate the grout to assure a solid and well bonded shear key.

After the grout is set, the contractor shall fill the area above the middepth shear key with an expansive polystyrene material. The District Engineer shall approve the material before it is used. After the fill material is placed, expanded and set, it shall be trimmed flush with the top of the beams.